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Sierra Nevada river incision from apatite $^4He/^3He$ thermochronometry

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Published erosion rates suggest that acceleration of river incision beginning some time before 3 Ma initiated formation of the deep river canyons in the southern Sierra Nevada. Such acceleration signals a change in erosional efficacy but its initial timing is poorly constrained. Increased erosional efficacy caused by elevation gain is predicted by scenarios such as block faulting, mantle lithosphere removal, and passage of a slab window. The timing and magnitude of elevation gain may be used to distinguish between competing mechanisms. As in many landscapes, the small magnitude ($<$ 1.5 km) and antiquity of river incision in the Sierra Nevada make the timing of landscape evolution and its relation to tectonic scenarios inaccessible by most methods. Until recently, we have lacked the potential to 'see' erosional events that exhume less than several kilometers and that occur over several to several tens of millions of years.

We present apatite He concentration profiles revealed by the recently developed $^4He/^3He$ method. The sensitivity to near surface temperatures of the apatite He concentration profile bridges the gap between bulk (U-Th)/He ages and cosmogenic ages, producing a continuum of long term and short term geomorphic rates. We analyzed a series of samples from a vertical profile in Kings Canyon where cooling was not instantaneous and where the helium concentration profile constrains a time-temperature path through roughly the last kilometer of exhumation. Preliminary data suggest that small amounts of bedrock incision ($<$ 1 km) produced thermal perturbations that are resolvable by this approach. We explore various thermal models that satisfy the helium age and concentration profile data alone and compare these results to geomorphic constraints and other rates derived from geologic and cosmogenic data. We also assess the reproducibility of $^4He/^3He$ data by analyzing replicate apatites from the same samples. Multiple samples from a vertical profile and replicate data from individual samples allow us to establish the self-consistency and reproducibility of the resulting cooling paths.